The Hawaiian Isles' Remarkable Effect on Atmospheric and Oceanic Circulation

Wind-wakes caused by islands should dissipate within 300 km downstream. The Hawaiian Islands, however, trigger an interaction between the atmosphere and ocean that extends thousands of miles downwind. Using data gathered by advanced satellite technology, **Shang-Ping Xie** (IPRC), **W. Timothy Liu** (Jet Propulsion Laboratory), **Qinyu Liu** (Qingdao University), and **Masami Nonaka** (IPRC and Frontier Research System for Global Change) were able to detect this interaction (Far-Reaching Effects of the Hawaiian Islands on the Pacific Ocean Atmosphere System, *Science*, **292**, 2001). The narrow, long break in the Pacific tradewinds stretches more than 3,000 km from the western side of the Hawaiian Islands to beyond Wake Island and includes an eastward jet imbedded in the westward-flowing North Equatorial Current.

Unraveling the dynamics of the eastward jet, the authors show in their analyses how tiny islands, barely visible on a world map, can affect a long stretch of Earth's largest ocean. When the westward trade winds impinge on the Hawaiian Islands, standing tall in the middle of the Pacific Ocean, the islands force the winds to split, creating areas of weak winds behind the islands and strong winds on the islands' flanks (panel a). Individual wakes form behind the islands, but these merge about 240 km to the west. A dipole wind curl leeward of the Hawaiian Islands spawns the narrow eastward current that draws warm water from west to east. The resulting SST gradient forces the winds from the north and the south to converge, weakening the northeasterly trades to the south of the warm tongue and intensifying them to the north. This feedback loop allows the wake and the wind curl pattern to persist over a great distance. The study suggests that surface winds react to sea-surface temperature variations as small as a few tenths of a degree, indicating a climate sensitivity much higher than has been previously thought.

To study more closely the nature of the eastward flowing current, a team of IPRC researchers—**Zuojun Yu, Nikolai Maximenko**, Shang-Ping Xie, and Masami Nonaka—looked at eddy-related features, as well as at the mean surface flow recorded by drifting buoys near the Islands (panel b). Between 160°W and the Island of Hawaii, the anticyclonic (cyclonic) eddies are generally smaller than 100 km (60 km) in radius, and their rotational velocities can reach 80 cm/s (panel c). The eddies may become larger as they propagate westward, and the rotational velocities of the anticyclonic (cyclonic) eddies are between 20–50 cm/s (20–30 cm/s).

Using this information as a guideline, Yu and her collaborators were able to simulate the eastward jet and to unravel its dynamics with a 2.5-layer model at 0.1° resolution. Reproduction of the observed jet required that vigorous eddies develop west of the islands. The eddies appear very similar to the cyclones and anticyclones in the observation and seem to be dominated by barotropic instabilities. The barotropic instabilities act to limit the westward extent of the jet by weakening the horizontal shear. The team's analysis is summarized in the manuscript "Eddy–mean flow interaction west of Hawaii" (submitted to *Journal of Physical Oceanography*). Together these studies help to understand the fascinating phenomena triggered by the Hawaiian Islands.

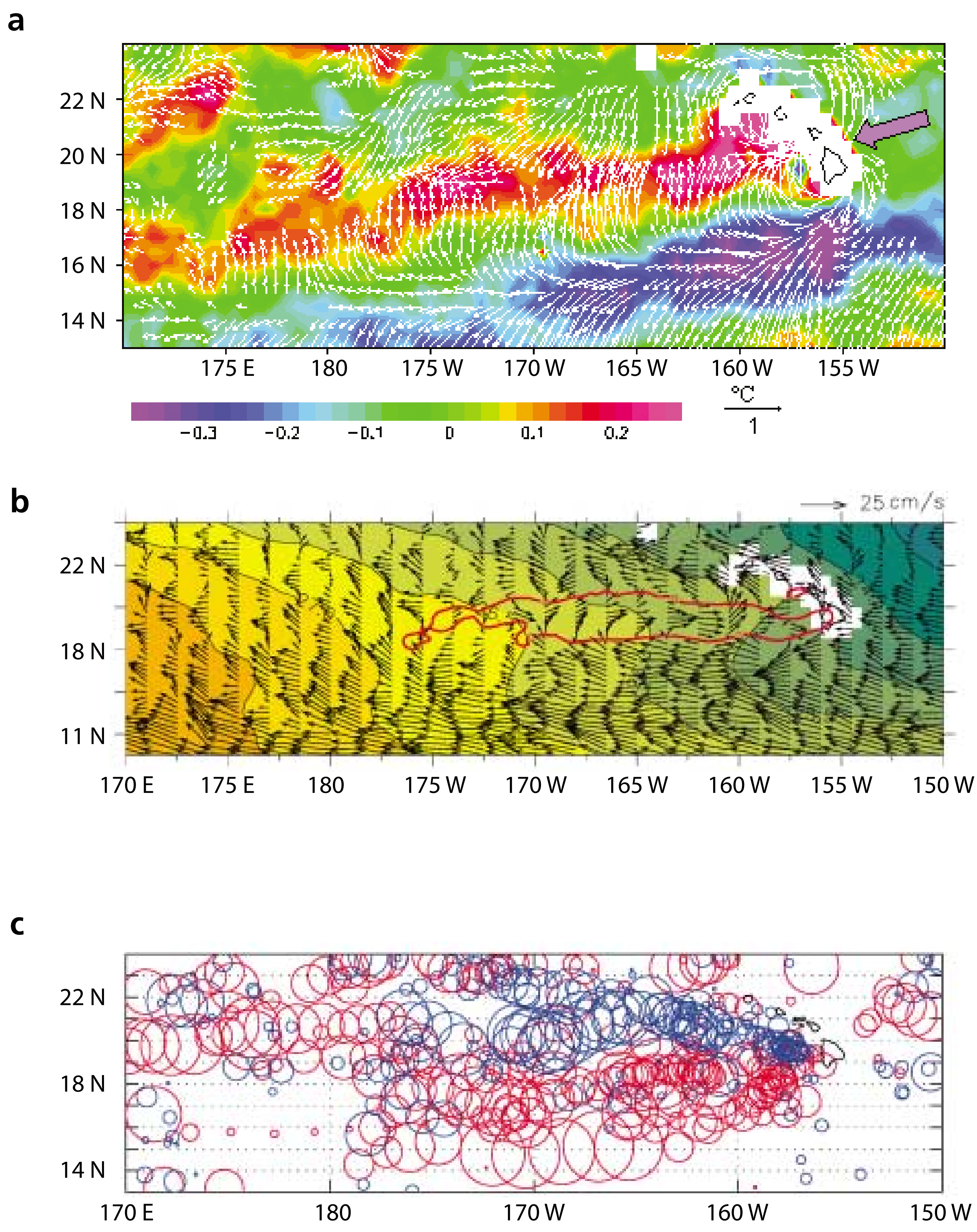

Figure 1. *The wind-wake of the Hawaiian Islands: (a) TRMM SSTs (high-pass filtered in the latitudinal direction to emphasize island effects; color scale in °C) and QuikSCAT wind vectors (m/s; the vector scale is also high-pass filtered and changed to 3 m/s east of 165°W); (b) mean surface currents from drifting buoy-data superimposed on annual mean SSTs based on 1999 TRMM data; and (c) eddy-related features derived from drifting-buoy data. The blue (red) circles indicate the locations and radii of cyclones (anticyclones).*

(Figure 1a is adapted with permission from Xie, Liu, Liu, Nonaka, 2001: Far-Reaching Effects of the Hawaiian Islands on the Pacific Ocean-Atmosphere System. Science, ***292****, 2057-2060. Copyright 2001American Association for the Advancement of Science.)*